# DISTRIBUTION, RELATIVE ABUNDANCE, AND ACTIVITY OF BAT SPECIES IN CRATER LAKE NATIONAL PARK, OREGON CAVES NATIONAL MONUMENT, AND REDWOOD NATIONAL AND STATE PARKS INCLUDING A COMPARISON OF LIVE CAPTURE AND ACOUSTICAL TECHNIQUES FOR DOCUMENTING SPECIES OCCURRENCE

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## EXECUTIVE SUMMARY

Scant information exists regarding the status, diversity, and distribution of bats throughout much of northern California and southern Oregon. As a result, biologists and land managers are unable to predict or evaluate the impacts that management activities such as habitat alteration, fire, and grazing practices have on the community of bats. Because bats are nocturnal and proficient at flight they are particularly difficult to inventory.

The objectives of this field study were to:

1) determine the diversity, relative abundance, and activity of bats in Crater Lake National Park (CRLA) and Redwood National and State Parks (REDW),
2) determine the distribution of bats in CRLA and REDW,
3) compare acoustical and live capture techniques for inventorying bats, and
4) determine the effect of bat friendly gates on bat activity at cave entrances in Oregon Caves National Monument (ORCA)

During the summers of 2004 and 2005, between 1 June and 13 October, I conducted bat inventories using mist nets, harp traps, and acoustical sampling in three of the Klamath Network (KLMN) parks: Crater Lake National Park (CRLA), Oregon Caves National Monument (ORCA), and Redwood National and State Parks (REDW). This inventory was designed to provide KLMN with a baseline dataset for bats fundamental in developing future monitoring efforts. Bats were captured using mist nets throughout the areas at a number of sites associated with water including springs, ponds, riparian areas, streams, and ephemeral water sources. Additionally, bats were captured using mist nets and harp traps at terrestrial sites including caves, and along secondary roads and hiking trails below the forest canopy. Acoustic monitoring was conducted using Anabat II echolocation detectors. Acoustical sampling was conducted at two types of sites, 1) actively and concurrently with mist netting efforts during the time nets were deployed and 2) statically for 9 hours (2000 until 0500) where mist netting was not conducted.

I captured 119 bats representing 6 species in mist nets during 24 nights (10,339 $m^2$ net hours of netting effort) between 8 August 2004 and 11 August 2005 in CRLA. Three species represented 68.1% of my mist net captures: silver-haired bats (*Lasionycteris noctivagans*) (26.1%), long-eared myotis (*Myotis evotis*) (21.0%), and long-legged myotis (*M. volans*) (21.0%).

During acoustical sampling, Anabat sequence files were recorded at 19 sites during 80 nights. At CRLA, 93.4% of the activity was represented by 3 species or species groups: 40 kHz myotis (long-legged myotis and little brown myotis [*M. lucifugus*]), (a mean of 41.1 passes per hour for the first 2.5 hours of the night), long-eared myotis (11.6), 50 kHz myotis (California myotis [*M. californicus*] and Yuma myotis *(M. yumanensis*]) (11.3).

Mist nets, harp traps, and acoustical sampling were used to survey bats in Oregon Caves National Monument (ORCA) between 7 and 16 September 2004. My primary objective at ORCA was to survey 2 cave entrances (Monument Deep and High Hopes) with mock gates present and absent to determine if gating the openings would affect bat activity. Based upon preliminary data, I noted no evidence that bat activity would be

affected by gates on the cave openings. At ORCA, I captured 4 species, long-eared myotis (40.0%), Townsend's big eared bat (*Corynorhinus townsendii*) (20.0%), California myotis (20.0%), and fringed myotis (*M. thysanodes*) (20.0%).

I captured 77 bats representing 9 species in mist nets during 25 nights (12,270 $m^2$ net hours of netting effort) between 21 September 2004 and 7 July 2005 in REDW. Two species represented 77.3% of my mist net captures: Yuma myotis (49.4%) and silver-haired bats (27.9%).

During acoustical sampling, Anabat sequence files were recorded at 20 sites during 57 nights. At REDW, 96.8% of the activity was represented by the 2 myotis species groups: 50 kHz myotis, (a mean of 42.5 passes per hour for the first 2.5 hours of the night) and 40 kHz myotis (25.7).

This study provides useful baseline information about bats that previously did not exist for CRLA and REDW. Measures of species diversity, relative abundance estimates, and activity indices are provided for all survey sites. These findings can be applied to the results of future efforts to help identify trends in bat activity at these specific locations. Additionally, I provide a comparison of live capture versus acoustical sampling methods at sites sampled concurrently. Recommendations are presented for the long-term monitoring of bats in the study areas.

## INTRODUCTION

Bats can present a number of difficulties in assessing and monitoring trends in their populations (O'Shea and Bogan 2003, O'Farrell and Gannon 1999*b*). Information regarding basic natural history, distribution, roosting preferences, and colony locations are lacking or limited for many bat species. Due to bats' vagility (i.e., ability of bats to move about or disperse in the environment) and their nocturnal activity patterns, inventory and monitoring of species distributions can be problematic. Live capture techniques and acoustical sampling used concurrently produce the most complete inventory, but either method deployed alone can present sampling limitations.

Because of their distinct requirements for roosting and foraging habitats, bat communities change when the structural or spatial characteristics of the vegetation are altered (Thomas and West 1988). Data about the distribution and abundance of bats enable resource managers to make better informed land management decisions (Morrell et al. 1999, Morrell and Duff 2005). Baseline inventories provide important information for future monitoring and to anticipate population responses to management activities. Recognizing the need to better understand the distribution and abundance of bat species in the parks, the Klamath Network Technical Committee selected bats as a group of special concern that warrants additional investigation by the Inventory and Monitoring Program (for more information see Acker et al. 2001).

Presently little is known about the distribution of bats at CRLA and REDW. One study conducted in REDW (Gellman and Zielinski 1996) indicated that large hollows in trees are important roost sites for bats within the park, although the authors primarily only reported species information to genus level based upon the guano observed at roost sites. Zielinski and Gellman (1999) documented seven bat species in Del Norte Coast

Redwoods State Park, but before this inventory those species present in the other management units of REDW were largely unknown. Conversely, considerable research has been conducted to determine bat community size, usage patterns, and potential use of acoustical detection at ORCA (see Cross 1977, Cross 1997, Whiteman 1997, Cross and Waldien 2002, and Cross and Waldien 2003 for results of these studies). Prior to this inventory, no information regarding distribution and abundance of bats existed in the literature for CRLA. Additionally, no studies in CRLA and REDW have systematically surveyed bats throughout the landscape. Therefore, it is possible that certain species have not yet been identified or have not been properly represented in previous inventories.

Much of the information obtained from inventorying bat species comes from either live captures using mist nets and harp traps (live capture techniques) or from acoustical sampling (O'Farrell and Gannon 1999*b*). However, not all species and not all individuals of a species are equally susceptible to either form of detection, primarily due to differences in use of space and variation in vocalization intensity among species (Thomas et al. 1987, O'Farrell and Gannon 1999*b*). Intraspecific variation in echolocation call structure may result from genetics, geographic areas, foraging habitats, communicative function, or morphological differences in vocal structures (Brigham et al. 1989). To compound documentation problems, alert bats that are actively foraging appear to detect and avoid live capture methods. Acoustical detectors permit sampling a larger area than do capture techniques, but may not adequately sample species that use low-intensity vocalizations (e.g., long-eared myotis, fringed myotis, and Townsend's big-eared bats) that are only detected at short distances (O'Farrell and Gannon 1999*b*). Both acoustical and live capture surveys conducted alone may result in an incomplete inventory that represents only a portion of the bat fauna where some species may be are missed completely. On Barro Colorado Island, Kalko et al. (1996) found after decades of intense sampling by capture, five additional species (7.5% increase) were detected using acoustical methods.

The objectives of this study were to: 1) determine the diversity, relative abundance, and activity of bats in CRLA and REDW, 2) determine the distribution of bats in CRLA and REDW, 3) compare acoustical and live capture techniques for inventorying bats, and 4) determine the effect of bat friendly gates on bat activity at cave entrances in ORCA.

**STUDY AREAS**

Crater Lake National Park is a 74,000 ha high elevation park that contains the deepest lake in the United States (594 m), located in southwestern Oregon on the divide of the Cascade Range. Elevations range from 1,219 to 2,720 m. Vegetation of the park is comprised primarily of coniferous forest. White fir (*Abies concolor*) and Douglas-fir (*Pseudotsuga menzesii*) are common on the wet western slope and ponderosa pine (*Pinus ponderosa*) and incense cedar (*Calocedrus decurrens*) forests dominate the drier eastern slope. At higher elevations, subalpine forests dominated by whitebark pine (*Pinus albicaulis*), mountain hemlock (*Tsuga mertensiana*), and patches of montane chaparral comprised of manzanita (*Arctostaphylos* spp.) and ceanothus (*Ceanothus* spp.) occur. In the northern area of the park, extensive monotypic lodgepole pine (*Pinus contorta*) forests are present. Wet and dry meadows, riparian areas, and rocky outcrops are also important nonconiferous habitats in the park. Mean maximum and minimum temperatures (C), and total precipitation (cm) at Crater Lake National Park, Oregon during the months I trapped bats were 4.8, 20.3, and 17.4, respectively (WRCC 2005).

Oregon Caves National Monument is a 196 ha park located in the Siskiyou Mountains of southwest Oregon just north of the California border. Elevations range from 1,122 to 1,670 m. Park vegetation is composed of mesic forests much like the west slope of CRLA, but also includes impressive stands of Port-Orford cedar (*Chamaecyparis lawsoniana*). Canyon live oak (*Quercus chrysolepis*) occurs at lower elevations on slopes with southern exposures. Herbaceous meadows are also found within the study area. Mean maximum and minimum temperatures (C), and total precipitation (cm) at Cave Junction, Oregon during September 2004 were 7.0, 28.6, and 2.0, respectively (WRCC 2005). Assuming a temperature lapse rate of 10° per 1000 m, this corresponds to mean maximum and minimum temperatures of approximately -1.0 and 20.6, respectively, at ORCA headquarters.

Redwood National and State Parks, is a group of 1 National Park (Redwood National Park) and 3 California State Parks (Prairie Creek Redwoods State Park, Del Norte Coast Redwoods State Park, and Jedediah Smith Redwoods State Park) managed collectively. Together the parks encompass 42,700 ha in northwestern California with 56 km of coastline on the Pacific Ocean. Elevations range from sea level to 996 m. Vegetation shows distinct zonation from the coast inland associated with penetration of salt spray and marine air masses. Along the salt-swept coast and adjacent bluffs, coastal prairies and shrubland vegetation predominate, with occasional stands of Sitka spruce (*Picea sitchensis*). Just inland, massive old-growth and second growth forest dominated by coast redwood (*Sequoia sempervirens*), Douglas-fir, and Tanoak (*Lithocarpus* *densiflorus*) occur. In the interior hills rising above the coastal fog zone, open Oregon white oak (*Quercus garryana*) savannas are present as well as extensive perennial grasslands. Hardwood trees, such as red alder (*Alnus rubra*) and big leaf maple (A*cer macrophyllum*) occur in riparian zones bisecting the coastal plain. Mean maximum and minimum temperatures (C), and total precipitation (cm) at Crescent City, California, a coastal station which is fairly representative of sites in the fog zone, during the months I trapped bats were 9.7, 18.4, and 32.4, respectively (WRCC 2005).

## METHODS

### Live Capture Techniques

I conducted opportunistic bat surveys using mist nets and harp traps during the summer and fall months. Mist net surveys were conducted in the study areas between 1 June and 13 October at 10 sites in CRLA, 1 site in ORCA, and 15 sites in REDW. Additionally, a collapsible harp trap (Bat Conservation Management, Inc., Generation 4 Cave Catcher) was deployed at 2 cave openings in ORCA. Bats were captured throughout the study area at sites including springs, ponds, riparian areas, streams, ephemeral water sources, cave openings, and along hiking trails and roads below the forest canopy. Nets were set in areas that either possessed shallow water (<1.5 m) or in upland areas where the combination of shrub and overhead canopy cover provided potential flyways for bats. Sampling efforts were partitioned spatially in all representative habitats and across elevational gradients while maximizing capture probabilities (netting over smooth water in aquatic sites or in locations with multiple corridors for commuting and foraging bats in terrestrial sites). One to 6 mist nets (2.6 m tall and ranged from 2.6 to 18 m in length) were set at each sampling site before sunset and remained in place for at least 2.5 hours. When I sampled a site more than once, I allowed at least 7 days to pass before the site was netted again. Netting sites were visited 1–5 times during the study. The location of capture, species, sex, reproductive status, and age of all captured bats was recorded and the bats were released unharmed (Kunz and Kurta 1988). The principal investigator determined age (juvenile or adult) by looking for the presence of cartilaginous epiphyseal plates in the phalanges (Anthony 1988). Most species were easily identifiable, but I closely examined the color and forearm length to distinguish the morphologically similar Yuma myotis and little brown myotis. Bats were identified as Yuma myotis if they were a dull light greyish brown with pale brown ears, and a forearm length of <36 mm, whereas bats were identified as little brown myotis if they were a dark silky sheen brown with brownish-black ears, and a forearm length >36 mm.

Relative abundance was determined for each species at each trap site by taking the number of bats captured x 1,000 and dividing by net effort (no. bats x 1,000/$m^2$ net effort/hour). Net effort was the total area ($m^2$) of net placed at a site times the amount of time (hours) the nets were set. For example, 3 nets (each 2.6 m high x 18 m long) set for 3 hours would result in 421.2 $m^2$ of net effort. I did not provide relative abundance at harp trap sites, but do provide a measure of harp trapping effort at ORCA. Harp effort was calculated by multiplying the height and width dimensions of the harp trap by the time it was deployed resulting in $m^2$ harp hours.

**Acoustical Sampling Techniques**

Acoustic monitoring was conducted using Anabat II echolocation detectors (Titley Electronics, Ballina, N.S.W., Australia). Detectors were coupled to an Anabat compact flash storage ZCA interface module (ZCAIM) and data were recorded directly to compact flash memory cards. Anabat data were subsequently downloaded to a computer's hard disk with the program CFCread, and archived for backup at Southern Oregon University. Acoustical sampling was conducted at two types of sites, 1) actively and concurrently with mist netting efforts during the time nets were deployed and 2) statically for 9 hours (2000 until 0500) where mist netting was not conducted. The combined Anabat sampling effort resulted in a grand total of 19 locations during 80 sample nights in CRLA and at 20 sites in REDW during 57 sample nights. At static sampling locations, detectors were propped at a 45° angle. When possible, I released bats representative of species captured within the study areas directly into Anabat detectors and recorded the species and time to aid in subsequent call identification in the laboratory.

Anabat information recorded during 2004 and 2005 was analyzed using the Analook analysis program. Reference calls and call characteristics were obtained from hand released bats captured during this study, the Anabat Bat Call Library (Corben and O'Farrell 2003), Sampling Methods for Bats (Thomas and West 1989), and from J. Szewczak, Humboldt State University, pers. comm. Species were assigned to species groupings according to their echolocation calls based upon maximum and minimum frequency, duration, and a general description of the call morphology. Some bats with overlapping echolocation calls were grouped into one of two general myotis groupings (40 kHz [long-legged myotis and little brown myotis] or 50 kHz myotis [California myotis and Yuma myotis]) while those bats with unique echolocation calls (long-eared myotis, silver-haired bats, big brown bats [*Eptesicus fuscus*], hoary bats [*Lasiurus cinereus*], Mexican free-tailed bats [*Tadarida brasiliensis*], and fringed myotis [*M. thysanodes*]) were grouped to an individual species level.

Two different activity indices were calculated, one for the active and concurrent sampling sites and another for the static (nightly) monitoring sites. For each species or species group at the concurrent sites, the activity index represented the average (across all sampling nights) number of passes (group of ≥2 consecutive calls in an Anabat sequence file) per hour for the first 2.5 hours of the night. Any Anabat sequence file with less than 2 consecutive calls and all sites with <2.5 hours of sampling were excluded from the calculation of the concurrent activity index. For each species or species group at the static sites, the nightly activity index represented both the mean and median (across all sampling nights) number of passes from 2000 to 0500. Because the mean is biased by sites or nights with an exceptionally high number of passes (i.e., Lagoon Creek at REDW) estimates of the median activity are provided in addition to estimates of the mean activity. Any Anabat sequence file with less than 2 consecutive calls was excluded from the calculation of the nightly activity index.

To evaluate efficiency of live capture and acoustical detection techniques, I compared number of times a species was detected by capture only, acoustic only, both methods simultaneously, and either method. That allowed a qualitative examination of susceptibility to each method by species or species group. A second comparison was made of the number of species or species group detected at each sampling event by capture and acoustic sampling separately using a Mann-Whitney *U*-Test (Zar, 1984).

## RESULTS

### Crater Lake National Park

At CRLA, 119 bats representing 6 species were captured in mist nets during 24 nights (10,339 $m^2$ net hours of netting effort) (Table 1). Three species represented 68.1% of my mist net captures: silver-haired bats (26.1%), long-eared myotis (21.0%), and long-legged myotis (21.0%). The remaining 31.9% of my captures consisted of Yuma myotis (16.0%), little brown myotis (11.8%), and big brown bats (4.1%). I was unsuccessful at capturing bats at 3 sites, Castle Crest Wildflower Trail, Pacific Crest Trail North Crater, and Ponderosa Pine Picnic Area.

Three sites provided 105 (88.2%) of all captures during 52.1% of all netting effort in CRLA. Vidae Falls Picnic Area, Boundary Springs, and Annie Spring provided the highest relative abundance estimates (Table 2). Long-eared myotis and Yuma myotis appeared to be the most widespread species being captured at 6 (60%) sites. Silver-haired bats were captured at 4 (40%) sites. At CRLA, most (87.4%) of my captures were males (Table 3).

In addition to live capture techniques, Anabat sequence files were recorded at 19 sites during 80 nights (Table 4). At CRLA, 93.4% of the activity during the first 2.5 hours of the night was represented by 3 species or species groups. Forty kHz myotis (long-legged myotis and little brown myotis), provided the highest bat activity (a mean of 41.1 passes per hour for the first 2.5 hours of the night). Long-eared myotis provided the second highest activity (11.6), followed by 50 kHz myotis (California myotis and Yuma myotis) (11.3). The remaining 6.6% of activity was represented by big brown bats (2.4), silver-haired bats (1.8), hoary bats (0.3), Mexican free-tailed bats (0.06), and California myotis (0.01).

Eight sites provided 72.7% of the activity during the first 2.5 hours of the night at CRLA, Wizard Island (a mean of 93.0 passes per hour for the first 2.5 hours of the night), Boundary Springs (69.0), Bear Creek (62.3), Munson Valley (62.2), Ponderosa Pine Picnic Area (58.0), Intersection of Wheeler Creek and Grayback Road (52.4), Spruce Lake (52.1), and Annie Spring (51.5) (Table 4). Median activity at the all night monitoring sites was 104.0 passes per night (Table 5). Four of 9 sites provided 78.3% of the activity at the static monitoring locations in CRLA, Wizard Island (a mean of 435.0 passes per night), Bear Creek (346.7), Spruce lake (233.3), and Sphagnum Bog (181.5) (Table 6). Based upon Anabat data collected during the first 2.5 hours of the night, 40 kHz myotis were most widespread, being documented at 19 (100.0%) sites, long-eared myotis were documented at 16 (84.2%), and 50 kHz myotis at 15 (78.9%) (Table 4).

Six species or species groups were captured, recorded, and analyzed during 19 sampling events at CRLA (Table 8). I recognized that both techniques likely missed species that were capable of avoiding the respective device or that flew outside the area sampled by these devices. However, for comparison, it was assumed that, at a given park, the total number of species detected by either method represented a complete inventory. Based upon that assumption, captures accounted for 32.3% and acoustic sampling 67.6% of the total occurrences. Where occurrences were documented by both methods at a sampling event, this accounted for 27.1% of the total occurrences. A greater number of species were detected by acoustic means than by capture for all sites combined. The number of species detected was greater for acoustic sampling than captures ($U = 45$, $P < 0.001$).

**Oregon Caves National Monument**

At ORCA, I captured 5 bats representing 4 species during 3 nights (343.2 $m^2$ net hours of netting effort in mist nets and 9.75 $m^2$ harp hours of effort) (Table 9). My primary objective at ORCA (at the request of John Roth) was to survey 2 cave entrances (Monument Deep and High Hopes) with mock gates present and absent to determine if gating the openings would affect bat activity. I also used a tarp at the 110 cave entrance to determine if restoring natural air flow to the opening would affect bat activity. Tarps were deployed so that approximately one-half of entrance gate was covered to mimic the natural entrance dimensions of the opening before it was expanded for an entrance/exit to the cave system.

The two focal sites, Monument Deep and High Hopes, were acoustically surveyed on 7 and 8 September with mock gates present (obstructed), and on 9, 10, and 13 September with mock gates absent (non-obstructed) (Table 10). At Monument Deep, an average of 32.5 Anabat sequence files were recorded at the gated opening and an average of 35.3 were recorded non-gated. At High Hopes an average of 30 sequence files were recorded gated and 12.5 sequence files non-gated (my non-gated estimate is based on 2 nights due to detector malfunction). Additionally, at the 110 cave entrance, 87 sequence files were recorded without the tarp deployed, and 80 sequence files were recorded with a tarp covering approximately one-half of the bat-friendly gate.

Long-eared myotis was the most commonly captured bat (40.0%), followed by Townsend’s big eared bat (*Corynorhinus townsendii*) (20.0%), California myotis

(20.0%), and fringed myotis (20.0%).  At ORCA, 100.0% of my captures were males. All of my bat captures came from harp traps; unfortunately I was unsuccessful capturing bats at the upper chalet pond using mist nets during two attempts.

**Redwood National and State Parks**

At REDW, 77 bats representing 9 species were captured in mist nets during 25 nights (12,270 $m^2$ net hours of netting effort) (Table 11).  Two species represented 77.3% of my mist net captures, Yuma myotis (49.4%) and silver-haired bats (27.9%).  The remaining 22.7% of the captures consisted of 7 species, California myotis (7.5%), big brown bats (5.1%), little brown bats (3.8%), hoary bats (2.4%), long-legged myotis (1.3%), Townsend's big-eared bats (1.3%), and pallid bats (*Antrozous pallidus*) (1.3%). At REDW, 58.4% of the captures were males (Table 12).  I was unsuccessful at capturing bats at 2 sites, Tall Tree Grove on Redwood Creek, and the Pool Near Minors Ridge Trailhead.  In addition to my captures, I visually observed 5 Townsend's big eared bats in the northernmost building at the World War II Radar Station on 22 September 2004.

Four sites provided 45 (60.0%) of all captures during 13.3% of all netting effort in REDW.  The Yurok Trail site provided the highest relative abundance estimate.  Prairie Creek, Elk Prairie (near bridge), and Lost Man Creek provided the second, third, and fourth highest relative abundance estimates (Table 13).  Yuma myotis appeared to be the most widespread species in REDW being captured at 10 locations (66.6%) each.  Silver-haired bats were captured at 4 (26.7%) sites.  Both big brown bats and little brown myotis were captured at 3 sites (20%).

In addition to live capture techniques, I recorded Anabat sequence files at 20 sites during 57 nights (Table 14).  At REDW, 96.8% of the activity during the first 2.5 hours of the night was represented by the 2 myotis species groups. Fifty kHz myotis provided the highest bat activity (a mean of 42.5 passes per hour for the first 2.5 hours of the night). Forty kHz myotis, provided the second highest activity (25.7). The remaining 4.2% of activity was represented by silver-haired bats (1.3), hoary bats (0.5), big brown bats (0.3), long-eared myotis (0.2), Mexican free-tailed bats (0.02), and fringed myotis (0.02).

Five sites provided 52.2% of the activity during the first 2.5 hours of the night at REDW, Redwood Creek (a mean of 88.0 passes per hour for the first 2.5 hours of the night), Lagoon Creek (67.0), Coastal Scrub Beach Pond (61.2), Espa Lagoon (47.0), and Mill Creek Site # 2 (45.0) (Table 14). Median activity at the all night monitoring sites was 90.0 passes per night (Table 15). Three of 7 sites provided 80.8% of the activity at the static monitoring locations in REDW, Lagoon Creek (a mean of 779.3 passes per night), Mill Creek on Howland Hill Road (354.5), and the Old Southern Operation Center (301.0) (Table 16). Based upon the Anabat data collected during the first 2.5 hours of the night, 40 and 50 kHz myotis were most widespread, being documented at 19 (95.0%) sites (Table 14). Big brown bats were documented at 6 (30.0%) sites.

Six species or species groups were captured, recorded, and analyzed during 17 sampling events at REDW (Table 18). I recognized that both techniques likely missed species that were capable of avoiding the respective device or that flew outside the area sampled by these devices. However, for comparison, it was assumed that, at a given park, the total number of species detected by either method represented a thorough and comprehensive inventory. Based upon that assumption, captures accounted for 35.8% and acoustic sampling 64.2% of the total recorded occurrences. For 25.4% of the total recorded occurrences, species were documented by both methods. A greater number of species were detected by acoustic means than by capture for all sites combined. The number of species detected was greater for acoustic sampling than for captures ($U$ = 55.5, $P$ = 0.002).

## DISCUSSION

This field study of three national park units in the Klamath Region demonstrated sharp contrasts in the summer bat fauna from unit to unit. For example, CRLA demonstrated higher bat abundance while REDW exhibited higher species diversity. I believe that REDW has higher species diversity than CRLA because the park has a more diverse array of habitats. Sixteen terrestrial vegetation types have been identified in REDW as opposed to just around 6 for CRLA (Odion et al. 2005). At REDW, two species (long-legged myotis and pallid bats) were captured only in a single netting site located in Oregon white oak woodland. Higher bat diversity in low elevation habitats has been documented elsewhere in KLMN (Morrell and Duff 2005, Duff and Morrell, In Press) as well as in bat surveys conducted in the North Cascades National Park Complex (Christophersen and Kuntz 2003).

Lower levels of bat abundance in REDW may be attributed to higher levels of precipitation during the survey months. Bats are affected by precipitation and many simply do not forage in the rain (Grindal et al. 1992). Precipitation can simultaneously reduce prey abundance and increase the energetic costs of homeothermy when the fur of terrestrial mammals become wet (Tuttle and Stevenson 1982). Precipitation can also make detecting prey by echolocation difficult (Griffin 1971). Erickson and West (2002) found in the Pacific Northwest that bat detections were highest in areas with lowest precipitation and warmest temperatures.  Minimum and maximum temperatures at CRLA were more variable (both higher and lower) during the trap season than those of REDW which are buffered by the Pacific Ocean.  I feel that precipitation had a major impact on the relative abundance and activity of bats at REDW and a landscape scale analysis of climatic influences (both temperature and precipitation patterns) on bat distribution across all KLMN parks with existing datasets (2001-2005) may be important to fully understand fully these relationships at the network level.

Because we did not survey for bats in the tall forest canopy at REDW, the activity and relative abundance estimates may not be representative of the overall bat community. In upland stands in the coastal plain of South Carolina, Menzel et al (2005) detected almost 4 times as many calls above the forest canopy as were detected within or below the canopy, and the relative difference in activity levels above and below the forest canopy differed among bat species.  The authors believe that acoustic monitoring protocols that monitor activity only below or within the canopy may under-represent stand use by bats adapted to forage in more open, uncluttered environments (e.g. hoary bats, big brown bats).

**Crater Lake National Park**

Based upon this inventory, I am confident that there are 9 species that should be included in park species lists for CRLA at this time.  These species include:  long-eared myotis, long-legged myotis, Yuma myotis, little brown myotis, California myotis, silver-haired bats, hoary bats, big brown bats, and Mexican free-tailed bats.

The summer bat fauna at CRLA was relatively species poor and skewed towards male captures. The sex ratio recorded at CRLA (87.4% male) was very similar to that from bat inventories conducted at LAVO during 2001-2003 where 89.0% of captures were males (Morrell and Duff 2005). Cryan et al. (2000) and others (Grindal et al. 1999, Fenton et al. 1980, Allen 1939) have reported elevational differences in distribution among sexes of insectivorous bats. Lower elevation habitats that are characterized by warmer temperatures than higher elevations may improve both foraging and thermoregulatory efficiencies of reproductive females (Cryan et al. 2000). Ambient temperature can influence aerial insect density and higher energetic demands imposed by pregnancy and lactation may necessitate greater food intake for reproductively active females than that required by males (Kunz 1974, Cryan et al. 2000).

Vidae Falls Picnic Area, Boundary Springs, and Annie Spring provided the highest relative abundance estimates and if future mist netting is conducted in order to determine sex ratios, number of juveniles, or monitor changes in species composition, efforts should be focused in these areas. If park managers are interested in monitoring change in activity, the static Anabat monitoring stations should be targeted and sampled at least 6-8 times. This will ensure that activity indices are robust and accurately represent activity at the park. The Wizard Island static monitoring site provided the highest Anabat activity and I feel that our findings were influenced by the presence of a diurnal or nocturnal roost in the area, possibly in the boat houses.

It is important to note that the index for 50 kHz myotis is mainly comprised of Yuma myotis passes, and California myotis was only documented at one site (Annie Spring). Additionally, small-footed myotis were not identified in Anabat analysis, and it is not listed as part of the 40 kHz activity index (although it is possible, but very unlikely, that it was documented and not distinguished). This species is typically associated with arid rangelands in Oregon (Whitaker et al. 1981), but relatively little is known regarding habitat and density (Verts and Carraway 1998). During other I&M surveys small-footed myotis have only been documented in Lava Beds National Monument (LABE). Thus I have no direct evidence to suggest that small-footed myotis is present in CRLA, and I feel that if the species were to be documented in the study area it would definitely be on the east side of the Cascades, or possibly as a migrant from the south.

**Oregon Caves National Monument**

Based on this study and past work completed by Cross (1977), Cross (1997), Whiteman (1997), and Cross and Waldien (2002), I am confident that there are 8 species that should be included in park species lists for ORCA at this time. These species include: long-eared myotis, long-legged myotis, Yuma myotis, little brown myotis, California myotis, fringed myotis, big brown bats, and Townsend's big-eared bats.

In this preliminary survey, I noted no evidence that bat activity would be affected by gates on the cave openings. Due to lack of crew expertise during 2004, the level of Anabat analysis at ORCA at the time this determination was made was far inferior to the detailed indices of activity provided in this report for CRLA and REDW. The acoustical results in this report for ORCA should be interpreted with extreme care, until further analysis can be performed on the sequence files. In terms of baseline information for species inventory at the monument the existing accounts in final reports of mark-recapture studies provide very good and detailed information that can be used to certify park species lists for bats.

## Redwood National and State Parks

Based upon this study and past work completed by Zielinski and Gellman (1999) and Gellman and Zielinski (1996) I am confident that there are 12 species that should be included in park species lists for REDW at this time. These species include: Yuma myotis, California myotis, long-legged myotis, little brown bats, big brown bats, hoary bats, silver-haired bats, Townsend's big-eared bats, pallid bats, Mexican free-tailed bats, and fringed myotis. Small-footed myotis was not differentiated in Anabat analysis, although based on existing distribution maps (BCI 2005, CDFG 2005) I do not feel that they exist in the study area.

The summer and fall bat fauna at REDW was relatively diverse and skewed towards female individuals. The sex ratio at REDW (41.6% female) contains a higher portion of females than CRLA, but is not quite what would be expected based upon the results of the Whiskeytown National Recreation Area (WHIS) inventory (67.5% female) (Morrell and Duff 2005). This may be due to the fact that many productive sample sites in WHIS were at low elevations near the reservoir, where foraging opportunities may have been higher than in respective habitats in REDW. In addition, higher levels of precipitation at REDW may have discouraged female occupancy because of the burden placed on those females that were reproductively active due to increased energetic costs of homeothermy and thermoregulatory efficiencies. It is also possible that this difference between parks is an artifact of the fact that the total captures at REDW were around 25% of those at WHIS (Morrell and Duff 2005).

Yuma myotis was the most abundant species captured at REDW, a result which is concurrent with the work of Zielinski and Gellman (1999). Silver-haired bats were captured at 4 sites, all of which were in old growth redwood habitat. This could be expected based upon previously published results (Perkins and Cross 1988, Thomas 1988, Verts and Carraway 1998, Hayes 2003). This species was the second most frequently captured in REDW and had the third highest activity index. This may be because during the first field season I sampled in fall when silver-haired bats were migrating through the area. On 12 October 2005, I captured 8 silver-haired bats at Lost Man Creek within 1 minute of each other where remaining captures were spread throughout the night. I hypothesize that this was a group of migrating silver-haired bats using the riparian area as a foraging and migration corridor late in the season. Zielinski and Gellman (1999) captured 6 times as many silver-haired bats during the fall as they did during the summer or winter months.

Yurok Trail, Lost Man Creek, Prairie Creek, and Elk Prairie (near bridge) provided the highest relative abundance estimates and if future mist netting is conducted in order to determine sex ratios, number of juveniles, or monitor changes in species composition, efforts should be focused in these areas. If park managers are interested in monitoring changes in activity, the static Anabat monitoring stations should be targeted and sampled at least 6–8 times to ensure robust activity indices.

**Live Capture and Acoustical Sampling Techniques**

Acoustical sampling with Anabat detectors can provide reliable activity indices as long as sufficient replication is obtained between samples. Hayes (1997) suggests that sampling a site fewer than 6–8 nights is likely to result in biased estimates of activity. Due to logistical and financial constraints, I was unable to sample every mist net site acoustically 6–8 times, but combining Anabat sampling with mist netting was beneficial in detecting the presence of species in the study area (e.g., at Annie Spring in CRLA, Anabat detected California myotis although concurrent mist netting didn't detect the species at this site). Conversely, without mist netting there wouldn't be much faith in myotis discrimination beyond the 50 kHz and 40 kHz groupings. I believe that combining Anabat and mist netting in bat inventories can improve the quality of presence/absence determinations for inventory and monitoring efforts and this has been documented elsewhere (see O'Farrell and Gannon 1999*b* and Mills et al. 1996). When it is important to rely on robust indices of activity, it is necessary to sample sites the recommended 6–8 times.

Based upon research conducted in the Northern Territory of Australia, Milne et al. (2004) suggest that when Anabat recordings are conducted over short periods for the purpose of general species inventory, active monitoring with hand-held detectors should be used as opposed to static recording techniques. Additionally, the authors recommended that minimum sampling time required to achieve a satisfactory (80%) inventory of bat species at a site is three hours. I suggest having detectors present at a mist netting site provides an indication of bat activity at the site during netting, and can aid in determining when (after the minimum 3 hours) sampling efforts should be concluded for the night, even if it does not produce reliable and robust activity indices.

Live capture techniques can provide information about the bat population that acoustical surveys cannot. Without capturing and handling the animals it is impossible to assess sex ratios, reproductive status, age, or parasite loading (O'Farrell and Gannon 1999*b*) or collect morphological measurements (forearm length and weight). Mist netting can provide estimates of relative abundance and diversity without the need for detailed analysis of specific calls which can be time consuming and expensive, but may be of a lesser quality than more robust activity indices based upon 6–8 nights of sampling.

Results of mist net surveys are easily tabulated and presented upon returning from the field, where acoustical information must be analyzed once researchers get back to the office, by a trained individual with extensive knowledge of habitats in area. Additionally, Anabat acoustical equipment is expensive to purchase whereas mist netting equipment can be assembled for approximately 1/3 the cost. Mist nets are most effectively operated by teams of 2 (one researcher and an assistant) whereas Anabat detectors could be deployed statically and analyzed by just one researcher. Alternatively if Anabat bat call analysis is contracted out to regional experts, data recording can be accomplished by a biological technician (GS-5) or volunteer with 2-4 hours of training in the Anabat sampling system. To effectively mist net and concurrently actively sample with Anabat, I recommend that there be at least one researcher or qualified wildlife biologist who possesses the appropriate training and state permits and two volunteer assistants to ensure that there are not gaps in the active monitoring in times of intense activity when two people are busy removing and processing bats.

While it is obvious that acoustical sampling can be a powerful tool for performing bat inventories, no single method provides a complete assessment of species presence. It is important to recognize that not just anyone with minimal training can deploy either method (O'Farrell et al. 1999*a*, O'Farrell et al 1999*b*) and produce an accurate inventory. The ability to identify species with the Anabat system is enhanced by use of a laptop computer, knowledge of conditions during data collection, and experience in the field. I feel that for accurate inventory and monitoring, it is important to concurrently deploy live capture and acoustical sampling techniques. If robust indices of activity are required then static sampling sites with 6–8 sampling nights should be collected each field season.

## MANAGEMENT IMPLICATIONS

Surveys used in this study were not conducted to determine population sizes. My results represent, at most, a relative index of bat activity of some species at sites when I surveyed them acoustically or by capturing bats. Probability of capture in mist nets differs among species and habitats. Nonetheless, I believe that my mist net results provide useful information on the distribution of some species in the study areas. Additionally, I believe that the results provide baseline data that can be used to monitor future distribution and activity trends. If management objectives include monitoring the distribution and relative abundances of bat species that are trappable with mist nets, I recommend that mist net surveys be conducted at each site at intervals of 2–5 years.

Additionally, I believe that acoustic techniques for documenting bat activity should be incorporated into future surveys. In locations where acoustical sampling was not initially deployed (i.e., WHIS), I recommend that follow up inventories be conducted to increase confidence in park-level species lists. Additionally, I suggest Anabat detectors be deployed at ORCA at sites with minimal clutter present and in habitats other than the cave. If these suggestions are followed, it is possible that additional bat species may be detected for park lists.

### Recommendations for Long-term Monitoring

Managing agencies should develop long-term monitoring programs that regularly document bat activity and identify and monitor use of their habitats. Recognizing that agencies are limited by time and budget constraints I recommend that at minimum, long-term monitoring programs regularly assess levels of bat activity in management areas, identify habitats receiving bat activity, survey caves, mines, and bridges for bat use, document and monitor roost sites in trees and snags, and investigate and monitor use of buildings and other structures by bats. Additionally, all agency personnel should be made aware that any information regarding bat activity is important and should be reported.

**Surveys**

No nationally recognized and accepted standardized bat survey protocol exists for the long-term monitoring of bat activity. Until this is achieved I suggest that long-term monitoring programs for bats conduct surveys using a combination of intensive net and acoustic surveys at stationary sites (e.g., all sites visited during this study). When possible, mist nets and Anabat surveys should be conducted simultaneously to ensure the most complete inventory of species. I suggest that surveys be conducted at a minimum of 2–5 year intervals. All representative habitats and elevations in an area should be surveyed. Because of the potentially tremendous variation in site use by bats, individual sites should be surveyed $\geq$3 times during a given summer field season with subsequent visits to a site occurring at intervals >7 days.

**Caves and Mines**

Because caves and mines are important habitat components for many species of bats, all caves and mines in a management area should be inventoried annually for bat activity. When possible, internal warm season surveys should be conducted to assess the level of bat activity in caves and mines. When internal surveys are not possible external monitoring should be performed using mist nets, harp traps, acoustic methods, or night vision equipment. Cold season internal surveys should be conducted annually to determine the importance of specific caves/mines as hibernacula.

### Bridges

Bridges and culverts often provide bats with useful roosting habitat. Some are used as day roost sites, while others are used primarily at night. All bridges and culverts should be monitored for bat activity at least once during the day and once during the night annually for bat activity. Surveyors should also closely look for the presence of guano beneath structures that are monitored even if no bats are observed.

### Roost Trees

Many species of bats frequently use living and dead trees (snags) as roost habitat. Bats are known to roost on or beneath bark, in holes or crevices, and in the foliage of live trees. When roost trees and snags are observed they should be documented and subsequently monitored at least once annually to evaluate the importance of the site to bats. Roost exit counts (counting the number of bats exiting a roost in the evening) and searches for guano around the base of roost trees and snags should be conducted at all sites with historic bat activity. Use of roost trees can be infrequent as some species often move from, and return to specific roosts. Thus, previously documented roost trees should continue to be monitored annually even if no recent documented use has occurred.

### Buildings

Bat use of buildings and other man-made structures should be documented. Buildings and structures that have received bat activity should be surveyed for bats and guano at least once a year to evaluate the importance of the structure to bats.

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# TABLES

Table 1. Capture locations, dates locations were surveyed, and frequencies of captures for all bats combined and 6 species of bats at Crater Lake National Park, 2004 and 2005.

| Capture Location | Dates | Total # Bats | Epfu | Lano | Myev | Mylu | Myvo | Myyu |
|---|---|---|---|---|---|---|---|---|
| Castle Crest Wildflower Trail | 8/15/2004, 8/3/2005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Intersection of Wheeler Creek and Grayback Road | 8/9/2004, 8/26/2004, 8/9/2005 | 4 | 1 | 0 | 1 | 0 | 0 | 2 |
| Boundary Springs | 7/20/2005, 8/10/2005 | 35 | 3 | 26 | 1 | 1 | 1 | 3 |
| Ponderosa Pine Picnic Area | 8/10/2004, 7/19/2005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pole Bridge Creek near Gravel Pit | 8/12/2004, 7/18/2005, 8/8/2005 | 4 | 0 | 0 | 4 | 0 | 0 | 0 |
| Annie Spring | 8/8/2004, 9/1/2004, 7/14/2005, 8/2/2005, 8/11/2005 | 25 | 0 | 1 | 13 | 4 | 4 | 3 |
| White Horse Ponds | 7/13/2005 | 2 | 1 | 0 | 0 | 0 | 0 | 1 |
| Munson Valley | 8/11/2004, 7/12/2005 | 4 | 0 | 2 | 1 | 0 | 0 | 1 |
| Vidae Falls Picnic Area | 8/8/2004, 8/25/2004, 7/11/2005 | 45 | 0 | 2 | 5 | 9 | 20 | 9 |
| Pacific Crest Trail North Crater | 8/19/2005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Epfu = Big brown bat (*Eptesicus fuscus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Myev = Long-eared myotis (*Myotis evotis*), Mylu = Little brown myotis (*M. lucifugus*), Myvo = Long-legged myotis (*M.volans*), Myyu = Yuma myotis (*M. yumanensis*)

Table 2. Capture locations, dates locations were surveyed, and relative abundance for all bats combined and 6 species of bats at Crater Lake National Park, 2004 and 2005.

| Capture Location | Dates | All Bats | Epfu | Lano | Myev | Mylu | Myvo | Myyu |
|---|---|---|---|---|---|---|---|---|
| Castle Crest Wildflower Trail | 8/15/2004, 8/3/2005 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Intersection of Wheeler Creek and Grayback Road | 8/9/2004, 8/26/2004, 8/9/2005 | 4.3 | 1.1 | 0.0 | 1.1 | 0.0 | 0.0 | 2.2 |
| Boundary Springs | 7/20/2005, 8/10/2005 | 34.0 | 2.9 | 25.3 | 1.0 | 1.0 | 1.0 | 2.9 |
| Ponderosa Pine Picnic Area | 8/10/2004, 7/19/2005 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pole Bridge Creek near Gravel Pit | 8/12/2004, 7/18/2005, 8/8/2005 | 2.3 | 0.0 | 0.0 | 2.3 | 0.0 | 0.0 | 0.0 |
| Annie Spring | 8/8/2004, 9/1/2004, 7/14/2005, 8/2/2005, 8/11/2005 | 11.5 | 0.0 | 0.5 | 6.0 | 1.8 | 1.8 | 1.4 |
| White Horse Ponds | 7/13/2005 | 8.5 | 4.3 | 0.0 | 0.0 | 0.0 | 0.0 | 4.3 |
| Munson Valley | 8/11/2004, 7/12/2005 | 4.3 | 0.0 | 2.2 | 1.1 | 0.0 | 0.0 | 1.1 |
| Vidae Falls Picnic Area | 8/8/2004, 8/25/2004, 7/11/2005 | 20.6 | 0.0 | 0.9 | 2.3 | 4.1 | 9.1 | 4.1 |
| Pacific Crest Trail | 8/19/2005 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | | |
| Crater Lake (Total Relative Abundance) | 8/8/2004 - 8/11/2005 | 11.5 | 0.5 | 3.0 | 2.4 | 1.4 | 2.4 | 1.8 |

Epfu = Big brown bat (*Eptesicus fuscus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Myev = Long-eared myotis (*Myotis evotis*), Mylu = Little brown myotis (*M. lucifugus*), Myvo = Long-legged myotis (*M.volans*), Myyu = Yuma myotis (*M. yumanensis*)

Table 3. Frequencies of captures of male and female bats by species in Crater Lake National Park, 2004 and 2005.

| Species | Female | Male | Total |
|---|---|---|---|
| Epfu | 0 | 5 | 5 |
| Lano | 2 | 29 | 31 |
| Myev | 10 | 15 | 25 |
| Mylu | 0 | 14 | 14 |
| Myvo | 1 | 24 | 25 |
| Myyu | 2 | 17 | 19 |
| Total | 15 | 104 | 119 |

Epfu = Big brown bat (*Eptesicus fuscus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Myev = Long-eared myotis (*Myotis evotis*), Mylu = Little brown myotis (*M. lucifugus*), Myvo = Long-legged myotis (*M.volans*), Myyu = Yuma myotis (*M. yumanensis*)

Table 4. Sampling locations, sampling type, number of nights, and activity index (average number of passes [group of ≥2 consecutive calls in an Anabat sequence file] per hour for the first 2.5 hours of the night) for all bats combined and 8 species or species group at Crater Lake National Park, 2004 and 2005.

| Sampling Location | Sampling Type | # Nights | Bat Activity | 40 kHz Activity | 50 kHz Activity | Myev Activity | Lano Activity | Epfu Activity | Laci Activity | Tabr Activity | Myca Activity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cloud Cap | Anabat Only | 7 | 2.2 | 1.2 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| Spagnum Bog | Anabat Only | 6 | 26.0 | 4.7 | 4.1 | 2.0 | 0.9 | 3.9 | 0.1 | 0.0 | 0.0 |
| Spruce Lake | Anabat Only | 6 | 52.1 | 33.5 | 7.5 | 4.3 | 2.3 | 0.1 | 0.1 | 0.0 | 0.0 |
| Ponderosa Pine #2 | Anabat Only | 7 | 34.7 | 11.9 | 13.4 | 0.9 | 1.3 | 0.2 | 0.9 | 0.0 | 0.0 |
| Phantom Ship | Anabat Only | 8 | 11.4 | 7.2 | 1.4 | 0.7 | 0.2 | 0.9 | 0.0 | 0.0 | 0.0 |
| Bear Creek | Anabat Only | 6 | 62.3 | 21.6 | 8.7 | 25.8 | 0.3 | 1.6 | 0.0 | 0.0 | 0.0 |
| Pumice Desert | Anabat Only | 8 | 4.0 | 0.8 | 0.0 | 0.3 | 0.1 | 0.9 | 0.0 | 0.0 | 0.0 |
| Wizard Island | Anabat Only | 5 | 93.0 | 78.7 | 5.8 | 1.0 | 0.1 | 0.6 | 0.0 | 0.1 | 0.0 |
| Pinnacles | Anabat Only | 7 | 9.3 | 2.3 | 1.1 | 0.2 | 0.5 | 0.7 | 0.0 | 0.1 | 0.0 |
| Vidae Ridge | Anabat Only | 2 | 0.6 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Vidae Fall Picnic Area | Anabat and Mistnet | 2 | 27.0 | 11.0 | 4.6 | 10.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Munson Valley | Anabat and Mistnet | 2 | 62.2 | 53.8 | 3.4 | 0.2 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| White Horse Ponds | Anabat and Mistnet | 1 | 13.6 | 10.4 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pole Bridge Creek near Gravel Pit | Anabat and Mistnet | 3 | 21.7 | 12.1 | 3.1 | 0.8 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 |
| Ponderosa Pine Picnic Area | Anabat and Mistnet | 1 | 58.0 | 38.8 | 8.4 | 0.0 | 0.0 | 1.2 | 0.0 | 0.0 | 0.0 |
| Boundary Springs | Anabat and Mistnet | 2 | 69.0 | 18.0 | 2.2 | 1.8 | 9.2 | 5.8 | 0.6 | 0.0 | 0.0 |
| Annie Spring | Anabat and Mistnet | 4 | 51.5 | 15.9 | 4.3 | 27.6 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 |
| Castle Crest Wildflower Trail | Anabat and Mistnet | 2 | 37.8 | 20.4 | 8.2 | 5.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Intersection of Wheeler Creek and Grayback Road | Anabat and Mistnet | 1 | 52.4 | 17.6 | 22.0 | 4.4 | 0.0 | 2.4 | 0.0 | 0.0 | 0.0 |
| | | | | | | | | | | | |
| Crater Lake (Total Activity) | Anabat and Mistnet | 80 | 80.0 | 41.1 | 11.3 | 11.6 | 1.8 | 2.4 | 0.3 | 0.06 | 0.01 |

40 kHz = (Myvo = Long-legged myotis [*Myotis volans*] and Mylu = Little brown myotis [*M. lucifugus*]), 50 kHz = (Myca = California myotis [*M. Californicus*] and Myyu = Yuma myotis [*M. yumanensis*]), Myev = Long-eared myotis (*M, evotis*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Epfu = Big brown bat (*Eptesicus fuscus*), Laci = Hoary bat (*Lasiurus cinereus*), Tabr = Mexican free-tailed bat (*Tadarida brasiliensis*), Myca = California myotis (*M. californicus*)

Table 5. Park, hours of sampling, number of bat passes, percentage of bat passes, mean number of bat passes, and median number of bat passes at static monitoring sites for all bats combined and 13 species or species groups at Crater Lake National Park, 2004 and 2005.

| Crater Lake National Park | | All Bats | Myotis | Non Myotis | 40 kHz | 50 kHz | Epfu | Epfu or Lano | Lano | Laci | Myca | Myev | Myth | Tabr | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hours of Sampling | 549.0 | | | | | | | | | | | | | | |
| # Passes | | 9,233 | 6,166 | 2,831 | 3,999 | 1,178. | 301 | 1,895 | 387 | 243 | 0.0 | 989 | 0.0 | 5 | 236 |
| % Passes | | 100.0 | 66.8 | 30.7 | 43.3 | 12.8 | 3.3 | 20.5 | 4.2 | 2.6 | 0.0 | 10.7 | 0.0 | 0.1 | 2.6 |
| Mean # Passes | | 151.4 | | | 65.6 | 19.3 | 4.9 | 31.1 | 6.3 | 4.0 | 0.0 | 16.2 | 0.0 | 0.1 | 3.9 |
| Median # Passes | | 104.0 | | | 21.0 | 8.0 | 2.0 | 18.0 | 2.0 | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 2.0 |

40 kHz = (Myvo = Long-legged myotis [*Myotis volans*] and Mylu = Little brown myotis [*M. lucifugus*]), 50 kHz = (Myca = California myotis [*M. Californicus*] and Myyu = Yuma myotis [*M. yumanensis*]), Epfu = Big brown bat (*Eptesicus fuscus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Laci = Hoary bat (*Lasiurus cinereus*), Myca = California myotis (*M. californicus*), Myev = Long-eared myotis (*M, evotis*), Myth = Fringed myotis (*M. thysanodes*), Tabr = Mexican free-tailed bat (*Tadarida brasiliensis*), and Other = Unidentifiable calls

Table 6. Survey locations, number of visits, and mean activity per site at static monitoring sites for all bats combined and 13 species or species groups at Crater Lake National Park, 2004 and 2005.

| Crater Lake National Park | Number of Visits | Bat Activity | 40 kHz | 50 kHz | Epfu | Epfu or Lano | Lano | Laci | Myca | Myev | Myth | Tabr | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beak Creek | 6 | 346.7 | 119.3 | 49.3 | 6.5 | 24.8 | 1.5 | 0.2 | 0.0 | 133.0 | 0.0 | 0.0 | 12.0 |
| Cloud Cap | 7 | 20.0 | 10.7 | 1.0 | 0.7 | 5.0 | 0.7 | 0.4 | 0.0 | 0.9 | 0.0 | 0.0 | 0.6 |
| Phantom Ship | 7 | 82.8 | 48.3 | 9.1 | 4.1 | 12.4 | 1.9 | 1.4 | 0.0 | 3.0 | 0.0 | 0.0 | 2.6 |
| Pinnacles | 7 | 65.1 | 19.0 | 4.6 | 5.0 | 27.0 | 2.0 | 0.1 | 0.0 | 1.4 | 0.0 | 0.3 | 5.8 |
| Ponderosa Pine # 2 | 7 | 141.3 | 34.4 | 36.7 | 1.3 | 48.4 | 12.1 | 3.0 | 0.0 | 2.4 | 0.0 | 0.0 | 2.9 |
| Pumice Desert | 6 | 22.1 | 5.8 | 0.8 | 3.8 | 9.0 | 2.4 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Spagnum Bog | 7 | 181.5 | 18.2 | 13.7 | 17.0 | 108.7 | 14.0 | 0.7 | 0.0 | 5.2 | 0.0 | 0.3 | 3.8 |
| Spruce Lake | 8 | 233.3 | 92.5 | 22.3 | 2.7 | 35.8 | 25.3 | 32.0 | 0.0 | 14.3 | 0.0 | 0.0 | 8.3 |
| Wizard Island | 5 | 435.0 | 343.8 | 57.2 | 5.4 | 23.6 | 0.4 | 1.2 | 0.0 | 3.2 | 0.0 | 0.2 | 0.0 |

40 kHz = (Myvo = Long-legged myotis [*Myotis volans*] and Mylu = Little brown myotis [*M. lucifugus*]), 50 kHz = (Myca = California myotis [*M. Californicus*] and Myyu = Yuma myotis [*M. yumanensis*]), Epfu = Big brown bat (*Eptesicus fuscus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Laci = Hoary bat (*Lasiurus cinereus*), Myca = California myotis (*M. californicus*), Myev = Long-eared myotis (*M, evotis*), Myth = Fringed myotis (*M. thysanodes*), Tabr = Mexican free-tailed bat (*Tadarida brasiliensis*), and Other = Unidentifiable calls

Table 7. Survey locations, number of visits, and median activity at static monitoring sites for all bats combined and 13 species or species groups at Crater Lake National Park, 2004 and 2005.

| Crater Lake National Park | Number of Visits | Bat Activity | 40 kHz | 50 kHz | Epfu | Epfu or Lano | Lano | Laci | Myca | Myev | Myth | Tabr | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beak Creek | 6 | 274.0 | 93.0 | 46.5 | 5.0 | 16.0 | 0.5 | 0.0 | 0.0 | 108.5 | 0.0 | 0.0 | 13.0 |
| Cloud Cap | 7 | 21.0 | 12.0 | 1.0 | 1.0 | 4.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Phantom Ship | 7 | 88.0 | 47.0 | 8.0 | 4.5 | 8.5 | 2.5 | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 3.0 |
| Pinnacles | 7 | 61.5 | 17.5 | 6.0 | 2.0 | 15.5 | 1.5 | 0.0 | 0.0 | 1.5 | 0.0 | 0.0 | 6.5 |
| Ponderosa Pine # 2 | 7 | 126.0 | 39.0 | 15.0 | 1.0 | 36.0 | 8.0 | 3.0 | 0.0 | 2.0 | 0.0 | 0.0 | 2.0 |
| Pumice Desert | 6 | 22.0 | 1.0 | 0.5 | 2.5 | 7.5 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Spagnum Bog | 7 | 188.5 | 13.5 | 8.5 | 15.5 | 117.0 | 11.5 | 0.5 | 0.0 | 5.5 | 0.0 | 0.0 | 4.0 |
| Spruce Lake | 8 | 234.5 | 127.0 | 15.0 | 2.0 | 30.0 | 19.5 | 11.5 | 0.0 | 11.5 | 0.0 | 0.0 | 8.0 |
| Wizard Island | 5 | 420.0 | 305.0 | 60.0 | 2.0 | 22.0 | 0.0 | 1.0 | 0.0 | 3.0 | 0.0 | 0.0 | 0.0 |

40 kHz = (Myvo = Long-legged myotis [*Myotis volans*] and Mylu = Little brown myotis [*M. lucifugus*]), 50 kHz = (Myca = California myotis [*M. Californicus*] and Myyu = Yuma myotis [*M. yumanensis*]), Epfu = Big brown bat (*Eptesicus fuscus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Laci =Hoary bat (*Lasiurus cinereus*), Myca = California myotis (*M. californicus*), Myev = Long-eared myotis (*M, evotis*), Myth = Fringed myotis (*M. thysanodes*), Tabr = Mexican free-tailed bat (*Tadarida brasiliensis*), and Other = Unidentifiable calls

Table 8. Summary of the occurrence of species for the first 2.5 hours of the night as determined by capture and acoustic methods at 19 sampling events in Crater Lake National Park, 2004 and 2005

| **Crater Lake National Park** | | | | |
|---|---|---|---|---|
| | Both Methods | Capture Alone | Acoustic Alone | Either Method |
| 40 kHz | 7 | 7 | 19 | 26 |
| 50 kHz | 6 | 6 | 18 | 24 |
| Myev | 8 | 11 | 15 | 26 |
| Lano | 2 | 4 | 3 | 7 |
| Epfu | 3 | 3 | 10 | 13 |
| Laci | 0 | 0 | 0 | 0 |
| | | | | |
| Total | 26 | 31 | 65 | 96 |

40 kHz = (Myvo = Long-legged myotis [*Myotis volans*] and Mylu = Little brown myotis [*M. lucifugus*]), 50 kHz = (Myca = California myotis [*M. Californicus*] and Myyu = Yuma myotis [*M. yumanensis*]), Myev = Long-eared myotis (*M, evotis*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Epfu = Big brown bat (*Eptesicus fuscus*), Laci = hoary bat (*Lasiurus cinereus*)

Table 9. Capture locations, dates, locations were surveyed, and frequencies of captures for 4 species of bats at Oregon Caves National Monument, 2004.

| Capture Location | Dates | Total # Bats | Myca | Myev | Myth | Coto |
|---|---|---|---|---|---|---|
| Gate at 110 exit | 9/15/2004 | 4 | 0 | 2 | 1 | 1 |
| Main cave tour entrance | 9/14/2004 | 1 | 1 | 0 | 0 | 0 |

Myca = California myotis (*Myotis californicus*), Myev = Long-eared myotis (*M. evotis*), Myth = Fringed myotis (*M. thysanodes*), and Coto = Townsend's big eared bat (*Corynorhinus townsendii*)

Table 10. Survey locations, dates locations were surveyed, presence of obstruction, number of Anabat sequence files, and general notes for mock gate study in Oregon Caves National Monument, 2004.

| Survey Location | Date | Cave Entrance Obstructed? | # Anabat Files | Notes |
|---|---|---|---|---|
| Monument Deep | 9/7/2004 | Yes | 0 | With Gate |
| Monument Deep | 9/8/2004 | Yes | 65 | With Gate |
| Monument Deep | 9/9/2004 | No | 67 | Without Gate |
| Monument Deep | 9/10/2004 | No | 33 | Without Gate |
| Monument Deep | 9/13/2004 | No | 6 | Without Gate |
| High Hopes | 9/7/2004 | Yes | 7 | With Gate |
| High Hopes | 9/8/2004 | Yes | 53 | With Gate |
| High Hopes | 9/9/2004 | No | 25 | Without Gate |
| High Hopes | 9/10/2004 | No | 0 | Without Gate, Detector Malfunction |
| High Hopes | 9/13/2004 | No | 0 | Without Gate |
| 110 Entrance | 9/13/2004 | No | 87 | Without Tarp |
| 110 Entrance | 9/14/2004 | Yes | 80 | With Tarp |

Table 11. Capture locations, dates locations were surveyed, and frequencies of captures for all bats and combined and 9 species of bats at Redwood National and State Parks, 2004 and 2005.

| Capture Location | Dates | Total # Bats | Anpa | Coto | Epfu | Laci | Lano | Myca | Mylu | Myvo | Myyu |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lyons Barn | 10/6/2004 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tall Tree Grove on Redwood Creek | 6/30/2005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pool Near Minors Ridge Trailhead | 9/30/2005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Redwood Creek | 9/29/2004 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Mill Creek Campground (Near Dump Station) | 9/22/2004, 10/7/2004, 6/9/2005 | 9 | 0 | 0 | 1 | 0 | 3 | 0 | 1 | 0 | 4 |
| Mill Creek off of Holland Hill Road | 9/23/2004, 6/13/2005 | 7 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 4 |
| Lost Man Creek | 10/12/2004, 6/14/2005 | 18 | 0 | 0 | 0 | 1 | 15 | 0 | 0 | 0 | 2 |
| Stout Grove | 9/21/2004, 10/5/2004, 6/15/2005 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Oak Woodland Bald Hills Road | 9/27/2004, 6/20/2005, 7/5/2005 | 7 | 1 | 0 | 2 | 0 | 0 | 2 | 1 | 1 | 0 |
| Fern Canyon | 10/4/2004, 6/21/2005 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Coastal Scrub Beach Pond | 6/22/2005. 7/6/2005 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Prairie Creek Zig-Zag Site | 6/23/2005 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Elk Prairie Near Bridge | 6/29/2005 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| Yurok Trail Site | 7/7/2005 | 15 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 11 |
| Prairie Creek | 10/13/2005 | 4 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 |

Anpa = Pallid bat (*Antrozous pallidus*), Coto = Townsend's big eared bat (*Corynorhinus townsendii*), Epfu = Big brown bat (*Eptesicus fuscus*), Laci = Hoary bat (*Lasiurus cinereus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Myca = California myotis (*Myotis californicus*), Mylu = Little brown myotis (*M. lucifugus*), Myvo = Long-legged myotis (*M.volans*), Myyu = Yuma myotis (*M. yumanensis*)

Table 12. Frequencies of captures of male and female bats by species in Redwood National and State Parks, 2004 and 2005.

| Species | Female | Male | Total |
|---|---|---|---|
| Anpa | 0 | 1 | 1 |
| Coto | 0 | 1 | 1 |
| Epfu | 1 | 2 | 3 |
| Laci | 1 | 1 | 2 |
| Lano | 6 | 16 | 22 |
| Myca | 3 | 3 | 6 |
| Mylu | 1 | 2 | 3 |
| Myvo | 0 | 1 | 1 |
| Myyu | 20 | 18 | 38 |
| Total | 32 | 45 | 77 |

Anpa = Pallid bat (*Antrozous pallidus*), Coto = Townsend's big eared bat (*Corynorhinus townsendii*), Epfu = Big brown bat (*Eptesicus fuscus*), Laci = Hoary bat (*Lasiurus cinereus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Myca = California myotis (*Myotis californicus*), Mylu = Little brown myotis (*M. lucifugus*), Myvo = Long-legged myotis (*M.volans*), Myyu = Yuma myotis (*M. yumanensis*)

Table 13. Capture locations, dates locations were surveyed and relative abundance for all bats combined and 9 species of bats at Redwood National and State Parks, 2004 and 2005.

| Capture Location | Dates | Bats | Anpa | Coto | Epfu | Laci | Lano | Myca | Mylu | Myvo | Myyu |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lyons Barn | 10/6/2004 | 4.3 | 0.0 | 4.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tall Tree Grove on Redwood Creek | 6/30/2005 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pool Near Minors Ridge Trailhead | 9/30/2005 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Redwood Creek | 9/29/2004 | 8.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.0 |
| Mill Creek Campground (Near Dump Station) | 9/22/2004, 10/7/2004, 6/9/2005 | 3.3 | 0.0 | 0.0 | 0.4 | 0.0 | 1.1 | 0.0 | 0.4 | 0.0 | 1.5 |
| Mill Creek off of Holland Hill Road | 9/23/2004, 6/13/2005 | 9.0 | 0.0 | 0.0 | 1.3 | 0.0 | 1.3 | 0.0 | 1.3 | 0.0 | 5.1 |
| Lost Man Creek | 10/12/2004, 6/14/2005 | 16.7 | 0.0 | 0.0 | 0.0 | 0.9 | 13.9 | 0.0 | 0.0 | 0.0 | 1.9 |
| Stout Grove | 9/21/2004, 10/5/2004, 6/15/2005 | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.9 |
| Oak Woodland Bald Hills Road | 9/27/2004, 6/20/2005, 7/5/2005 | 5.6 | 0.8 | 0.0 | 1.6 | 0.0 | 0.0 | 1.6 | 0.8 | 0.8 | 0.0 |
| Fern Canyon | 10/4/2004, 6/21/2005 | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.9 |
| Coastal Scrub Beach Pond | 6/22/2005. 7/6/2005 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| Prairie Creek Zig Zag Site | 6/23/2005 | 11.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11.4 |
| Elk Prairie (near bridge) | 6/29/2005 | 21.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.4 |
| Yurok Trail Site | 7/7/2005 | 443.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 118.3 | 0.0 | 0.0 | 325.4 |
| Prairie Creek | 10/13/2005 | 28.5 | 0.0 | 0.0 | 0.0 | 7.1 | 21.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | | | | | |
| Redwood (Total Relative Abundance) | 9/21/2004 – 7/7/2005 | 6.4 | 0.1 | 0.1 | 0.3 | 0.2 | 1.8 | 0.5 | 0.2 | 0.1 | 3.2 |

Anpa = Pallid bat (*Antrozous pallidus*), Coto = Townsend's big eared bat (*Corynorhinus townsendii*), Epfu = Big brown bat (*Eptesicus fuscus*), Laci = Hoary bat (*Lasiurus cinereus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Myca = California myotis (*Myotis californicus*), Mylu = Little brown myotis (*M. lucifugus*), Myvo = Long-legged myotis (*M.volans*), Myyu = Yuma myotis (*M. yumanensis*)

Table 14. Survey locations, sampling type, number of nights, and activity index (average number of passes [group of ≥2 consecutive calls in an Anabat sequence file] per hour for the first 2.5 hours of the night) for all bats combined and 8 species or species group in Redwood National and State Parks, 2004 and 2005.

| **Sampling Location** | **Sampling Type** | **Nights** | **Bat Activity** | **40 kHz Activity** | **50 kHz Activity** | **Myev Activity** | **Lano Activity** | **Epfu Activity** | **Laci Activity** | **Tabr Activity** | **Myth Activity** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Holter Ridge | Anabat Only | 6 | 3.0 | 0.5 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Lagoon Creek | Anabat Only | 5 | 67.0 | 23.4 | 27.8 | 0.0 | 4.4 | 0.3 | 0.0 | 0.1 | 0.1 |
| Dolason Prairie | Anabat Only | 7 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Espa Lagoon | Anabat Only | 8 | 47.0 | 26.1 | 19.7 | 0.0 | 0.4 | 0.0 | 0.1 | 0.0 | 0.0 |
| Mill Creek Site #2 | Anabat Only | 2 | 45.0 | 2.6 | 42.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Marshall Pond | Anabat Only | 4 | 29.9 | 23.2 | 6.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Old Southern Operations Center | Anabat Only | 4 | 27.8 | 7.9 | 17.4 | 0.5 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 |
| Mill Creek Campground | Anabat and Mistnet | 3 | 35.5 | 5.7 | 25.6 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 |
| Mill Creek off of Holland Hill Road | Anabat and Mistnet | 1 | 2.4 | 0.0 | 2.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Lost Man Creek | Anabat and Mistnet | 2 | 34.0 | 0.2 | 31.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 |
| Stout Grove | Anabat and Mistnet | 3 | 30.1 | 1.2 | 28.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Oak Woodland Bald Hills Road | Anabat and Mistnet | 4 | 34.9 | 9.6 | 20.9 | 0.8 | 0.0 | 0.9 | 0.0 | 0.0 | 0.0 |
| Fern Canyon | Anabat and Mistnet | 1 | 17.6 | 2.0 | 15.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Coastal Scrub Beach Pond | Anabat and Mistnet | 1 | 61.2 | 33.2 | 23.2 | 0.0 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Elk Prairie Near Bridge | Anabat and Mistnet | 1 | 11.2 | 4.8 | 5.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tall Tree Grove on Redwood Creek | Anabat and Mistnet | 1 | 9.6 | 1.6 | 7.2 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Yurok Trail Site | Anabat and Mistnet | 1 | 23.2 | 1.2 | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Redwood Creek | Anabat and Mistnet | 1 | 88.0 | 7.2 | 80.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pool Near Minors Ridge Trailhead | Anabat and Mistnet | 1 | 16.0 | 1.2 | 14.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Prairie Creek | Anabat and Mistnet | 1 | 7.2 | 0.8 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | | | | | |
| Redwood (Total Activity) | Anabat and Mistnet | 57 | 76.4 | 25.7 | 43.5 | 0.2 | 1.3 | 0.3 | 0.5 | 0.02 | 0.02 |

40 kHz = (Myvo = Long-legged myotis [*Myotis volans*] and Mylu = Little brown myotis [*M. lucifugus*]), 50 kHz = (Myca = California myotis [*M. Californicus*] and Myyu = Yuma myotis [*M. yumanensis*]), Myev = Long-eared myotis (*M, evotis*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Epfu = Big brown bat (*Eptesicus fuscus*), Laci = hoary bat (*Lasiurus cinereus*), Tabr = Mexican free-tailed bat (*Tadarida brasiliensis*), Myth = fringed myotis (*M. thysanodes*)

Table 15. Park, hours of sampling, number of bat passes, percentage of bat passes, mean number of bat passes, and median number of bat passes at static monitoring sites for all bats combined and 13 species or species groups at Redwoods National and State Parks, 2004 and 2005.

| Redwood National and State Parks | | All Bats | Myotis | Non Myotis | 40 kHz | 50 kHz | Epfu | Epfu or Lano | Lano | Laci | Myca | Myev | Myth | Tabr | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hours of Sampling | 315.0 | | | | | | | | | | | | | | |
| # Passes | | 7,213 | 6,782 | 336 | 3,059 | 3,715 | 14 | 167 | 101 | 53 | 4 | 3 | 1 | 1 | 95 |
| % Passes | | 100.0 | 94.0 | 4.7 | 42.4 | 51.5 | 0.2 | 2.3 | 1.4 | 0.7 | 0.1 | 0.0 | 0.0 | 0.0 | 1.3 |
| Mean # Passes | | 206.1 | | | 87.4 | 106.1 | 0.4 | 4.8 | 2.9 | 1.5 | 0.1 | 0.1 | 0.0 | 0.0 | 2.7 |
| Median # Passes | | 90.0 | | | 11.0 | 23.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

40 kHz = (Myvo = Long-legged myotis [*Myotis volans*] and Mylu = Little brown myotis [*M. lucifugus*]), 50 kHz = (Myca = California myotis [*M. Californicus*] and Myyu = Yuma myotis [*M. yumanensis*]), Epfu = Big brown bat (*Eptesicus fuscus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Laci = Hoary bat (*Lasiurus cinereus*), Myca = California myotis (*M. californicus*), Myev = Long-eared myotis (*M, evotis*), Myth = Fringed myotis (*M. thysanodes*), Tabr = Mexican free-tailed bat (*Tadarida brasiliensis*), and Other = Unidentifiable calls

Table 16. Survey locations, number of visits, and mean activity per site at static monitoring sites for all bats combined and 13 species or species groups at Redwoods National and State Parks, 2004 and 2005.

| **Redwood National and State Parks** | **Number of Visits** | **Bat Activity** | **40 kHz** | **50 kHz** | **Epfu** | **Epfu or Lano** | **Lano** | **Laci** | **Myca** | **Myev** | **Myth** | **Tabr** | **Other** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dolason Prarie | 6 | 0.4 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Espa Lagoon | 8 | 193.1 | 111.6 | 78.3 | 0.0 | 1.0 | 1.6 | 0.5 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mill Creek on Howland Hill Road | 2 | 354.5 | 8.0 | 341.0 | 0.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| Holter Ridge | 6 | 19.8 | 2.0 | 17.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Lagoon Creek | 5 | 779.3 | 378.0 | 313.0 | 2.8 | 31.0 | 19.8 | 10.5 | 0.3 | 0.0 | 0.3 | 0.3 | 23.5 |
| Marshall Pond | 7 | 127.5 | 88.0 | 34.8 | 0.3 | 2.3 | 1.8 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Old Southern Operations Center | 4 | 301.0 | 68.0 | 225.8 | 0.3 | 4.0 | 0.5 | 1.3 | 0.5 | 0.8 | 0.0 | 0.0 | 0.0 |

40 kHz = (Myvo = Long-legged myotis [*Myotis volans*] and Mylu = Little brown myotis [*M. lucifugus*]), 50 kHz = (Myca = California myotis [*M. Californicus*] and Myyu = Yuma myotis [*M. yumanensis*]), Epfu = Big brown bat (*Eptesicus fuscus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Laci = Hoary bat (*Lasiurus cinereus*), Myca = California myotis (*M. californicus*), Myev = Long-eared myotis (*M, evotis*), Myth = Fringed myotis (*M. thysanodes*), Tabr = Mexican free-tailed bat (*Tadarida brasiliensis*), and Other = Unidentifiable calls

Table 17. Survey locations, number of visits, and median activity at static monitoring sites for all bats combined and 13 species or species groups at Redwoods National and State Parks, 2004 and 2005.

| Redwood National and State Parks | Number of Visits | Bat Activity | 40 kHz | 50 kHz | Epfu | Epfu or Lano | Lano | Laci | Myca | Myev | Myth | Tabr | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dolason Prarie | 6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Espa Lagoon | 8 | 203.0 | 105.5 | 32.5 | 0.0 | 0.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mill Creek on Howland Hill Road | 2 | 354.5 | 8.0 | 341.0 | 0.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| Holter Ridge | 6 | 20.5 | 3.0 | 17.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Lagoon Creek | 5 | 874.0 | 303.5 | 195.5 | 0.5 | 37.5 | 11.5 | 9.5 | 0.0 | 0.0 | 0.0 | 0.0 | 22.5 |
| Marshall Pond | 7 | 111.0 | 78.0 | 30.5 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Old Southern Operations Center | 4 | 206.0 | 28.5 | 71.5 | 0.0 | 4.5 | 0.5 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 |

40 kHz = (Myvo = Long-legged myotis [*Myotis volans*] and Mylu = Little brown myotis [*M. lucifugus*]), 50 kHz = (Myca = California myotis [*M. Californicus*] and Myyu = Yuma myotis [*M. yumanensis*]), Epfu = Big brown bat (*Eptesicus fuscus*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Laci = Hoary bat (*Lasiurus cinereus*), Myca = California myotis (*M. californicus*), Myev = Long-eared myotis (*M, evotis*), Myth = Fringed myotis (*M. thysanodes*), Tabr = Mexican free-tailed bat (*Tadarida brasiliensis*), and Other = Unidentifiable calls

Table 18. Summary of the occurrence of species for the first 2.5 hours of the night as determined by capture and acoustic methods at 17 sampling events in Redwood National and State Parks, 2004 and 2005.

| **Redwood National and State Parks** | | | | |
|---|---|---|---|---|
| | Both Methods | Capture Alone | Acoustic Alone | Either Method |
| 40 kHz | 4 | 4 | 16 | 20 |
| 50 kHz | 10 | 11 | 16 | 27 |
| Myev | 0 | 0 | 3 | 3 |
| Lano | 1 | 4 | 2 | 6 |
| Epfu | 2 | 3 | 5 | 8 |
| Laci | 0 | 2 | 1 | 3 |
| | | | | |
| Total | 17 | 24 | 43 | 67 |

40 kHz = (Myvo = Long-legged myotis [*Myotis volans*] and Mylu = Little brown myotis [*M. lucifugus*]), 50 kHz = (Myca = California myotis [*M. Californicus*] and Myyu = Yuma myotis [*M. yumanensis*]), Myev = Long-eared myotis (*M, evotis*), Lano = Silver-haired bat (*Lasionycteris noctivagans*), Epfu = Big brown bat (*Eptesicus fuscus*), Laci = hoary bat (*Lasiurus cinereus*)

## APPENDIX

Appendix A. Park, site, description, sampling type, X coordinate, Y coordinate, coordinate system units, UTM zone, map datum, horizontal error, and accuracy notes for all sampling sites located in Crater Lake National Park and Redwood National and State Parks, 2004 and 2005.

| Park | Site | Description | Sampling Type | X Coord. | Y Coord. | Units | Coord. System | UTM Zone | Map Datum | Horizontal Error | Accuracy Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CRLA | WHPND1 | White Horse Ponds | Mist Netting and Active Anabat | 565582 | 4747464 | Meters | UTM | 10 | NAD83 | 4 | Garmin V Differentially Corrected |
| CRLA | MUNVA1 | Munson Valley | Mist Netting and Active Anabat | 570374 | 4747544 | Meters | UTM | 10 | NAD83 | 5 | Garmin V Differentially Corrected |
| CRLA | ANSPR1 | Annie Spring | Mist Netting and Active Anabat | 567876 | 4746959 | Meters | UTM | 10 | NAD83 | 6 | Garmin V Differentially Corrected |
| CRLA | PLBRC1 | Pole Bridge Creek near Gravel Pit | Mist Netting and Active Anabat | 569627 | 4743815 | Meters | UTM | 10 | NAD83 | 6 | Garmin V Differentially Corrected |
| CRLA | PPINE1 | Ponderosa Pine Picnic Area | Mist Netting and Active Anabat | 576688 | 4736232 | Meters | UTM | 10 | NAD83 | 7 | Garmin V Differentially Corrected |
| CRLA | BNDSP1 | Boundary Springs | Mist Netting and Active Anabat | 562413 | 4769063 | Meters | UTM | 10 | NAD83 | 6 | Garmin V Differentially Corrected |
| CRLA | WHCGB1 | Intersection of Wheeler Creek and Grayback Road | Mist Netting and Active Anabat | 577330 | 4747775 | Meters | UTM | 10 | NAD83 | 9 | Garmin V Differentially Corrected |
| CRLA | PCTNC2 | Pacific Crest Trail | Mist Netting and Active Anabat | 573881 | 4770880 | Meters | UTM | 10 | NAD83 | 7 | Garmin V Differentially Corrected |

| Park | Site | Description | Sampling Type | X Coord. | Y Coord. | Units | Coord. System | UTM Zone | Map Datum | Horizontal Error | Accuracy Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CRLA | CCWFT1 | Castle Crest Wildflower Trail | Mist Netting and Active Anabat | 570883 | 4749078 | Meters | UTM | 10 | NAD83 | 6 | Garmin V Differentially Corrected |
| CRLA | VIDAE1 | Vidae Fall Picnic Area | Mist Netting and Active Anabat | 573566 | 4748106 | Meters | UTM | 10 | NAD83 | 7 | Garmin V Differentially Corrected |
| CRLA | CLCAP1 | Cloud Cap | Static Anabat | 577900 | 4754315 | Meters | UTM | 10 | NAD83 | 5 | Garmin V Differentially Corrected |
| CRLA | SPBOG1 | Spagnum Bog | Static Anabat | 561102 | 4760813 | Meters | UTM | 10 | NAD83 | 7 | Garmin V Differentially Corrected |
| CRLA | CFNVF1 | Vidae Ridge | Static Anabat | 573466 | 4749731 | Meters | UTM | 10 | NAD83 | 2 | Garmin V Differentially Corrected |
| CRLA | SPRUC1 | Spruce Lake | Static Anabat | 557345 | 4758729 | Meters | UTM | 10 | NAD83 | 8 | Garmin V Differentially Corrected |
| CRLA | PPPINE2 | Ponderosa Pine | Static Anabat | 575906 | 4738699 | Meters | UTM | 10 | NAD83 | 7 | Garmin V Differentially Corrected |
| CRLA | PHANT1 | Phantom Ship | Static Anabat | 575942 | 4751790 | Meters | UTM | 10 | NAD83 | 3 | Garmin V Differentially Corrected |
| CRLA | BEARC1 | Bear Creek | Static Anabat | 583260 | 4759063 | Meters | UTM | 10 | NAD83 | 8 | Garmin V Differentially Corrected |
| CRLA | PUMDS1 | Pumice Desert | Static Anabat | 571973 | 4764106 | Meters | UTM | 10 | NAD83 | 5 | Garmin V Differentially Corrected |

| Park | Site | Description | Sampling Type | X Coord. | Y Coord. | Units | Coord. System | UTM Zone | Map Datum | Horizontal Error | Accuracy Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CRLA | WZRD1 | Wizard Island | Static Anabat | 569427 | 4753835 | Meters | UTM | 10 | NAD83 | 3 | Garmin V Differentially Corrected |
| CRLA | PINNA1 | Pinnacles | Static Anabat | 581280 | 4744623 | Meters | UTM | 10 | NAD83 | 2 | Garmin V Differentially Corrected |
| REDW | YURTR1 | Yurok Trail Site | Mist Netting and Active Anabat | 408153 | 4605335 | Meters | UTM | 10 | NAD83 | 2 | Garmin V Differentially Corrected |
| REDW | MICRK1 | Mill Creek off of Holland Hill Road | Mist Netting and Active Anabat | 408164 | 4624871 | Meters | UTM | 10 | NAD83 | 2 | Garmin V Differentially Corrected |
| REDW | LOMNC1 | Lost Man Creek | Mist Netting and Active Anabat | 414997 | 4575631 | Meters | UTM | 10 | NAD83 | 3 | Garmin V Differentially Corrected |
| REDW | STOGV1 | Stout Grove | Mist Netting and Active Anabat | 409879 | 4627155 | Meters | UTM | 10 | NAD83 | 2 | Garmin V Differentially Corrected |
| REDW | OAKWO1 | Oak Woodland Bald Hills Road | Mist Netting and Active Anabat | 427656 | 4553688 | Meters | UTM | 10 | NAD83 | 5 | Garmin V Differentially Corrected |
| REDW | FERNC1 | Fern Canyon | Mist Netting and Active Anabat | 411156 | 4584044 | Meters | UTM | 10 | NAD83 | 3 | Garmin V Differentially Corrected |
| REDW | BEACH1 | Coastal Scrub Beach Pond | Mist Netting and Active Anabat | 411032 | 4584770 | Meters | UTM | 10 | NAD83 | 2 | Garmin V Differentially Corrected |

| Park | Site | Description | Sampling Type | X Coord. | Y Coord. | Units | Coord. System | UTM Zone | Map Datum | Horizontal Error | Accuracy Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| REDW | PCZZG1 | Prairie Creek Site | Mist Netting and Active Anabat | 415015 | 4581003 | Meters | UTM | 10 | NAD83 | 10 | Garmin V Not Differentially Corrected |
| REDW | TTGRC1 | Tall Tree Grove on Redwood Creek | Mist Netting and Active Anabat | 415199 | 4562281 | Meters | UTM | 10 | NAD83 | 0 | Garmin V Differentially Corrected |
| REDW | MICAM2 | Mill Creek Campground (Near Dump Station) | Mist Netting and Active Anabat | 408843 | 4617094 | Meters | UTM | 10 | NAD83 | 3 | Garmin V Differentially Corrected |
| REDW | LYBAR1 | Lyons Barn | Mist Netting and Active Anabat | 423372 | 4554324 | Meters | UTM | 10 | NAD83 | 3 | Garmin V Differentially Corrected |
| REDW | PRCRK1 | Prairie Creek | Mist Netting and Active Anabat | 413777 | 4584265 | Meters | UTM | 10 | NAD83 | 4 | Garmin V Differentially Corrected |
| REDW | MIRIP1 | Pool Near Minors Ridge Trailhead | Mist Netting and Active Anabat | 410738 | 4582062 | Meters | UTM | 10 | NAD83 | 1 | Garmin V Differentially Corrected |
| REDW | RDCRK1 | Redwood Creek | Mist Netting and Active Anabat | 413110 | 4572218 | Meters | UTM | 10 | NAD83 | 7 | Garmin V Differentially Corrected |
| REDW | ELPRB1 | Elk Prairie Near Bridge | Mist Netting and Active Anabat | 412693 | 4574569 | Meters | UTM | 10 | NAD83 | 0 | Geographic coordinates obtained in GIS |

| Park | Site | Description | Sampling Type | X Coord. | Y Coord. | Units | Coord. System | UTM Zone | Map Datum | Horizontal Error | Accuracy Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| REDW | HORIB1 | Holter Ridge | Static Anabat | 419887 | 4576142 | Meters | UTM | 10 | NAD83 | 2 | Garmin V Differentially Corrected |
| REDW | LAGCR1 | Lagoon Creek | Static Anabat | 408450 | 4605221 | Meters | UTM | 10 | NAD83 | 5 | Garmin V Differentially Corrected |
| REDW | DONPR1 | Dolason Prarie | Static Anabat | 420333 | 4561814 | Meters | UTM | 10 | NAD83 | 0 | Garmin V Differentially Corrected |
| REDW | ESPAL1 | Espa Lagoon | Static Anabat | 410321 | 4578902 | Meters | UTM | 10 | NAD83 | 10 | Garmin V Differentially Corrected |
| REDW | HHMCR2 | Mill Creek on Howland Hill Road | Static Anabat | 408658 | 4624755 | Meters | UTM | 10 | NAD83 | 3 | Garmin V Differentially Corrected |
| REDW | MARPN1 | Marshall Pond | Static Anabat | 412379 | 4597521 | Meters | UTM | 10 | NAD83 | 7 | Garmin V Differentially Corrected |
| REDW | OLSOC1 | Old Southern Operations Center | Static Anabat | 410166 | 4569748 | Meters | UTM | 10 | NAD83 | 4 | Garmin V Differentially Corrected |